DOCUMENT RESUME

ED 317 955 CS 010 002

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TITLE Phonemic Effects in Text Comprehension and Text Memory.
PUB DATE Apr 90
NOTE 8p.; Paper presented at the Annual Meeting of the American Educational Research Association (Boston, MA, April 15-21, 1990).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Analysis of Variance; Cues; *Distinctive Features (Language); Higher Education; *Memory; *Phonemes; *Reading Comprehension; Reading Processes; Reading Rate; Reading Research; Silent Reading; Text Structure; Young Adults
IDENTIFIERS *Phonemic Awareness; Reader Expectations; Text Factors

ABSTRACT

A study investigated the role of phonemic (sound-based) information during silent reading to determine whether the visual tongue-twister effect occurs only when readers make judgments of sentence acceptability or whether the visual tongue-twister effect is due to the way sentences are represented in memory. Data were collected from 45 university undergraduates, who were asked to respond to 24 sentence triads. Within each triad, two sentences contained phonemic confusions (visual tongue-twisters) and one was a control sentence that contained a natural mix of word-initial phonemes and formed an approximate semantic paraphrase of one of the tongue-twisters. Two-word memory probes were created for 16 of the sentence triads. Reading times for the sentences, response times to the probes, and response accuracy were recorded. Results revealed that adult readers took significantly longer to read tongue-twisters than to read control sentences. Adult readers also took significantly longer to respond to memory probes from tongue-twisters than from those of control sentences. There were no significant differences in response accuracy to the three probe types (control sentence, alveolar tongue-twister, and fricative tongue-twister). The findings suggest that sound-based information is still used by skilled adult readers during sentence comprehension. Examples of the three types of stimuli and data results are included. (KEH)

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ED317955

American Educational Research Association

Annual Meeting, Boston, Mass. -- April 16-20, 1990

Phonemic Effects in Text Comprehension & Text Memory

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Theoretical Framework:

This study investigated the role of phonemic (sound-based) information during silent reading. Perfetti and McCutchen (1982) observed that skilled adult readers take longer to read silently a sentence that contains phonemic confusions, e.g., *The detective discovered the danger and decided to dig for details*, than a comparable sentence with a normal mix of word-initial phonemes, e.g., *The investigator knew the hazard and chose to hunt for answers.* They proposed a model of reading in which phonological information enhances the representations of words within working memory by helping differentiate them and secure respective order. When the representations of words in working memory are very similar phonologically, the phonological enhancements lose their informational value, confusion results, comprehension suffers, and reading is slowed.

In Perfetti & McCutchen's (1982) model of reading, sentence comprehension is the result of integrating phonetically-indexed lexical representations in a temporary working memory buffer. As each succeeding lexical item is accessed, its representation is added to the others already stored in working memory. These representations contain both semantic and phonological features that are automatically activated during lexical acces Together they provide a unique reference to the lexical item, one that differentiates the items in working memory and aids in the reaccess of specific lexical items, when

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necessary. The hypothesis, very simply, is that phonological information enhances the lexical representations within working memory by helping differentiate them. If, however, the lexical representations in working memory are very similar phonologically, as they are in tongue-twisters, the phonological enhancements lose their informational value, and comprehension suffers. When many phonologically similar representations fill the memory buffer, they cause the kinds of similarity confusions often observed in memory tasks (e.g., Conrad, 1964). Such confusions generally have to be resolved before comprehension can proceed; thus tongue-twisters require more time to read and comprehend than sentences containing a normal mix of word-initial phonemes. In essence, the visual tongue-twister effect might be thought of as a phonological replication of Neisser's (1963) visual scanning task: The more similar the items being scanned (in a visual array or memory) the more time required to make precise identifications.

The Visual Tongue-Twister Effect: It takes adults longer to silently read phonemically confusing sentences (visual tongue-twisters) than control sentences matched on the basis of semantic content, grammatical structure and word frequency.

Previous studies of this phonemic effect (McCutchen & Perfetti, 1982; McCutchen, Bell, France & Perfetti, in press) required subjects to make sentence acceptability judgments; that is, subjects read both semantically acceptable and unacceptable sentences, and then classified the sentences as acceptable or unacceptable. Adult readers took longer to read and judge the acceptability of visual tongue-twister sentences than control sentences.

The present study extended previous findings by addressing two questions:

(1) Does the visual tongue-twister effect occur only when people make judgements of sentence acceptability? If this effect reflects a more general property of

sentence comprehension, reading times for tongue-twisters should be slower than reading times for matched control sentences when people are reading for comprehension and immediately recalling some of the sentences.

(2) Is the visual tongue-twister effect due to the way sentences are represented in memory, as suggested by Perfetti & McCutchen (1982)? If so, people should be slower to respond to questions requiring recall of tongue-twister sentences than control sentences.

The present experiment included only grammatical sentences to ensure that the phonemic effect was not an artifact of the acceptability paradigm. To guarantee that subjects indeed read and processed the sentences, the present study included periodic memory probes which required subjects to reaccess their memory of the sentence just read.

Methods & Procedures:

Subjects were 45 university undergraduates. Subjects were asked to read simple sentences, presented individually on a computer screen. As subjects finished reading each sentence, they pressed the space bar to present the next stimulus. For one third of the sentences, the next stimulus was another sentence. On the remaining trials, the next stimulus was a two word memory probe containing words taken from the previous sentence. Subjects were required to decide whether the two words appeared in the probe in the same order as they had appeared in the previous sentence, pressing the appropriately labeled button when they had decided. Reading times for the sentences and response times to the probes, and response accuracy were recorded by an Apple IIe microcomputer.

Stimulus materials consisted of 24 sentence triads, with sentences in each triad following the same syntactic pattern. Within each triad, two sentences contained phonemic confusions (i.e., were visual tongue-twisters) and one was a control

sentence that contained a natural mix of word-initial phonemes and formed an approximate semantic paraphrase of one of the tongue-twisters. Thus, sets of yoked triads were created, holding constant semantic content and syntactic structure while varying phonemic content. Sentences were presented in random sequence.

Two-word memory probes were created for 16 of the sentence triads (48 of the sentences). Each probe consisted of two content words from the sentence which it followed. In 24 of the probes, the words were in the same order as they had appeared in the original sentence; in 24 probes the order was reversed. The content words selected for inclusion in the probes were constant across each triad.

Examples of Stimuli:

(Control sentence)

His exaggerated stories were believed as fact by his friends.

(Memory probe)

STORIES FACT

(Alveolar tongue-twister)

His tall tales were taken as truth by the twins.

(Memory probe)

TALES TRUTH

(Fricative tongue-twister)

The scholarly subject was seen as serious by the scientist.

(Memory probe)

SUBJECT SERIOUS

Results:

	Sentence Type		
	Control	Alveolar	Fricative
Reading Times (sec)	3.890	4.001	4.037
Response Times (sec)	2.054	2.112	2.111
Response Accuracy (% correct)	.91	.93	.91

Adult readers took significantly longer to read tongue-twisters than control sentences. Adult readers also took significantly longer to respond to memory probes from tongue-twisters than from control sentences. There were no significant differences in response accuracy to the three probe types.

Reading times (for all 72 sentences) and response times (to the 48 probes) were analyzed as a repeated measures ANOVA within an overall MANOVA. The MANOVA of sentence reading times yielded a significant omnibus F, $p<.01$, with the pre-planned univariate tests revealing a significant difference between control and tongue-twister sentences, $F(1,44)= 8.12$, $p<.01$, and no significant difference between the two sets of tongue-twisters, $F(1.44)=1.07$, $p=.3l$. Thus, the phonemic effect reported by Perfetti and McCutchen (1982) was replicated in reading times.

The pattern of response times to the memory probes also revealed the tongue-twister effect in pre-planned univariate tests, with probes to tongue-twisters requiring longer response times than control probes, $F(1,44)= 5.58$, $p= .02$, and no difference between the two sets of tongue-twister probes, $F<1$. The phonemic effect was also replicated in time required to respond to the memory probes.

Conclusions:

It is well-understood that sound-based information can be helpful to beginning readers in word identification. The present study demonstrates that sound-based information is still used by skilled adult readers during sentence comprehension. In order to respond accurately to the memory probes, subjects had to reaccess their memory representation of the sentence just read, scan that representation to retrieve the order of the probed words, and then respond appropriately. More time was required to reaccess and scan the representations of tongue-twisters (i.e., sentences containing many words with similar phonological indexes), just as more time was required to comprehend such sentences initially. There were no significant differences in response accuracy to the three types of memory probes, suggesting that in this task the tongue-twisters and control sentences were comprehended and recalled equally well.

Since the same effect appears in the reading task and the memory task, it seems likely the effect has a similar source -- the temporary memory buffer that is used during comprehension and reaccessed in response to the probes in this task. Given the strong evidence as to the acoustic nature of working memory (e.g., Baddeley & Hitch, 1974; Conrad, 1964), it is likely the tongue-twister effect, which was documented in sentence memory as well as sentence comprehension, is phonological.

These findings indicate that sound-based information plays a role well beyond reading acquisition: it may help illuminate the relationship between early word-identification and later comprehension skill. The sounds of words may aid the reading comprehension process by helping readers distinguish these words in working memory during the construction of sentence meaning. Sound information may also help in maintaining sequencing of words in working memory (Shankweiler & Crain, 1986).

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